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Heat Stress Assessment for Dairy Cattle in Zambia

John Mutua and Noah Sikaceya

7 June 2021

Choma, Zambia

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Program

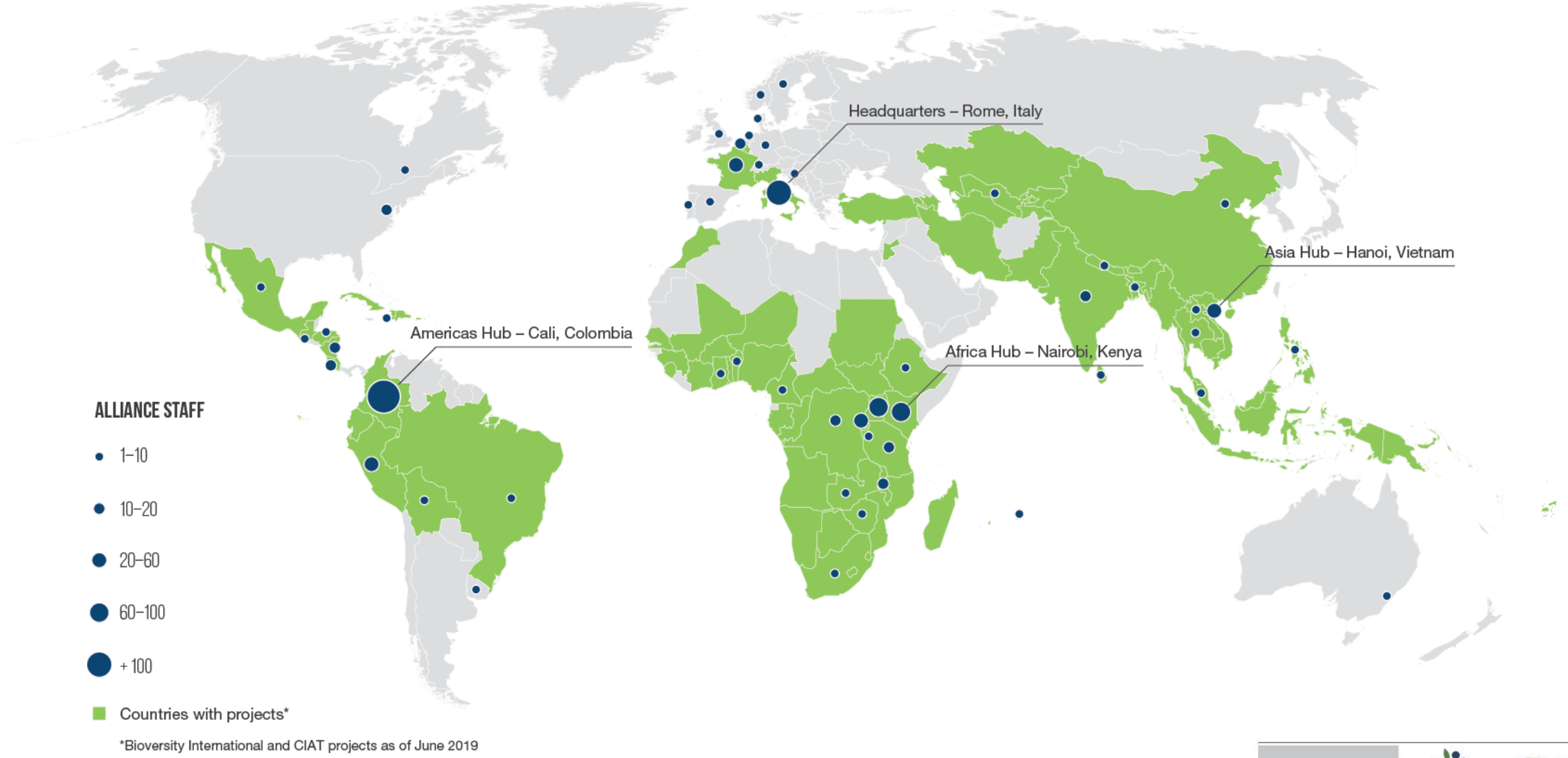
TIME	ACTIVITY	RESPONSIBLE
	DAY 1	
08:30 - 09:00	Welcome remarks and Introductions	Noah
09:00 - 09:45	Present and discuss heat stress analysis results (historic and future trends) for Zambia	John
09:45 - 10:45	Group Activity: Value chain characterization - Key activities, actors, scale of operation	Noah
10:45 - 11:15	COFFEE BREAK	
11:15 - 11:45	Group presentation on VC characterization and key insights	John
11:45 - 12:45	Group Activity: Risk matrix Identify key risks for the selected value chain - Heat stress consequences for the value chain activities - What are underlying vulnerability factors (Climatic, Biophysical, Social, Economic, and Institutional) and impacts of heat stress to the selected value chains	Noah
12:45 - 14:00	LUNCH	
14:00 - 14:30	Group presentation on risks and key insights	Noah
14:30 - 15:30	Group Activity: Adaptation options - Identify current ongoing adaptation options across the value chain stages - What are proposed/potential heat stress adaptation strategies (what is possible to do in the current program and future/other programs)	John
15:30 - 16:30	Group presentation on adaptation options and key insights	Noah
	DAY 2	
09:00 - 10:30	Plenary: Formulate high-level priority actions to support adaptation to future heat stress	John
10:30 - 11:00	COFFEE BREAK	
11:00 - 12:00	Next steps and evaluation	Noah

Objectives

- Present and discuss heat stress analysis (historic and future trends) for Zambia.
- Assess the key risks and consequences across the dairy value chain.
- Identify on-going and potential adaptation options across the dairy chain.
- Formulate high-level priority actions to support adaption to future heat stress

Opening Remarks

Where we work



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Lever 1

Food environment and consumer behavior

Lever 2

Multifunctional landscapes

Lever 3

Climate action

Lever 4

Biodiversity for food and agriculture

Lever 5

Digital inclusion

Lever 6

Crops for nutrition and health

Vision and Mission

VISION

Food systems and landscapes that sustain the planet, drive prosperity and nourish people

MISSION

We deliver research-based solutions that harness agricultural biodiversity and sustainably transform food systems to improve people's lives in a climate crisis

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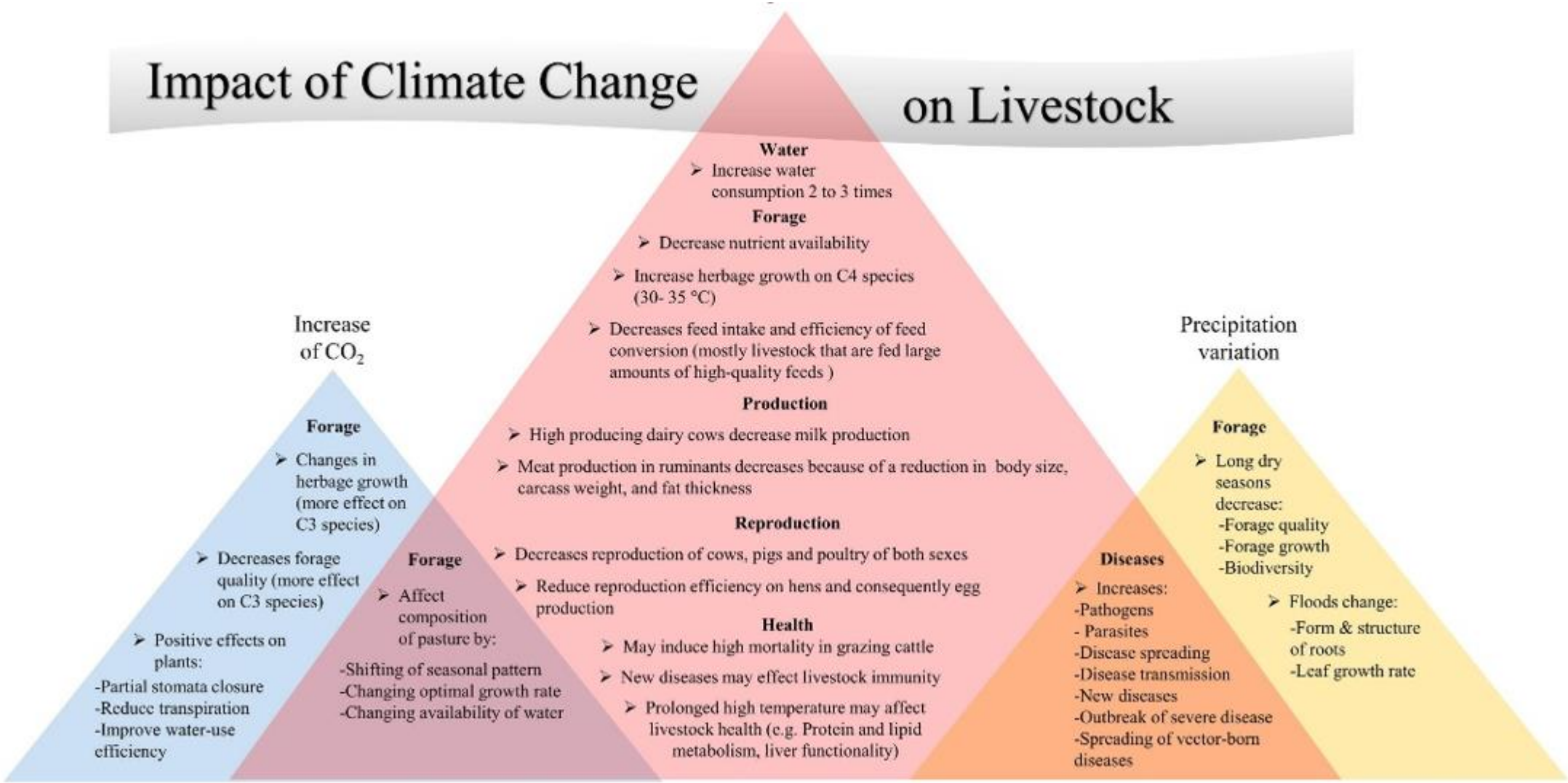
Climate change

- Rising temperatures.
- Increase in heavy precipitation (heavy rain and hail)
- Increase in hunger and water crises
- Health risks due to rising temperatures and heatwaves
- Increasing spread of pests and pathogens

Source: https://aventar.eu/tag/alteracoes-climaticas



Global demand for livestock products is expected to double by 2050!

Rojas-Downing *et al.*, 2017

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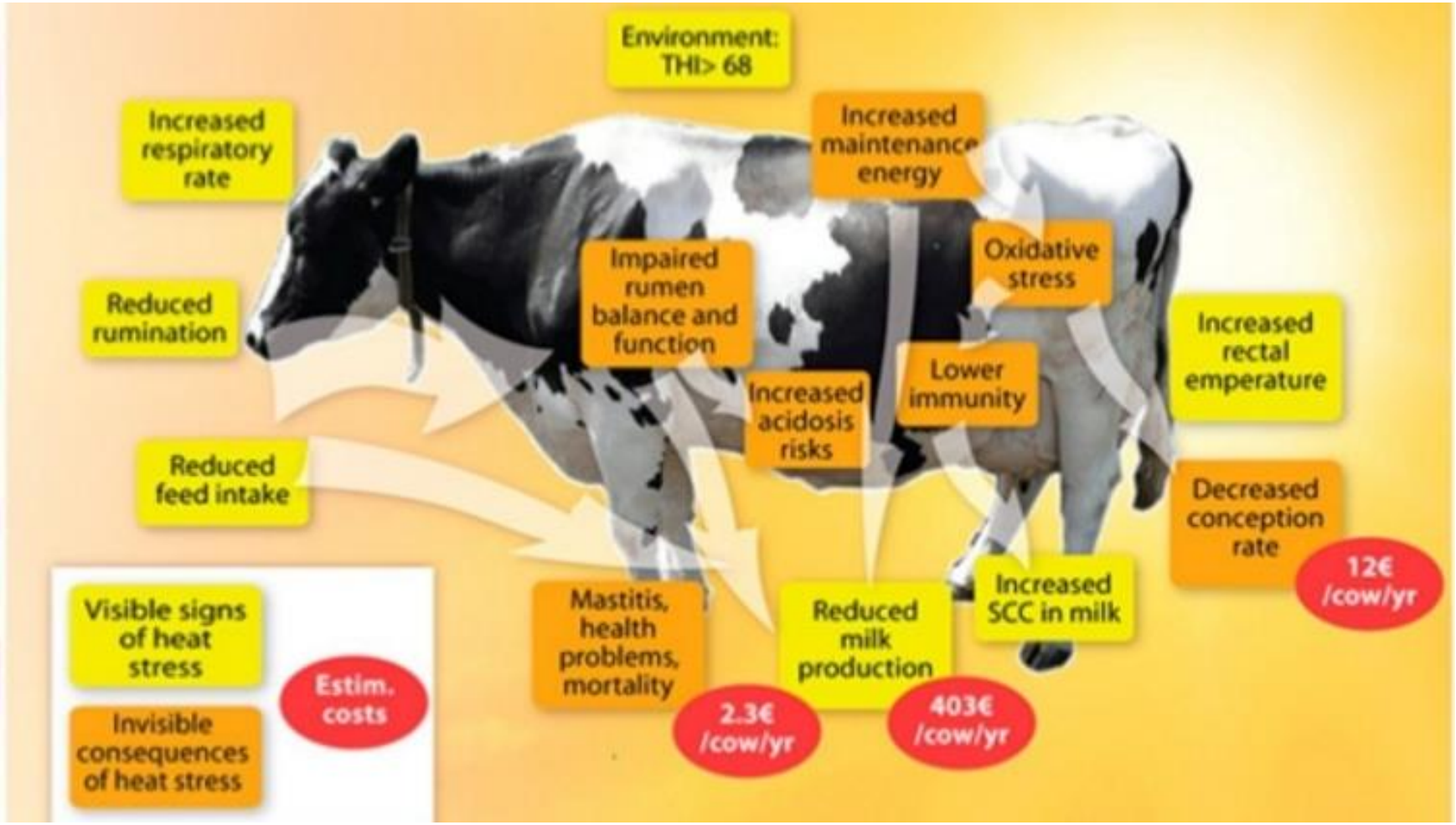
Heat stress and livestock

- Exposure to heat stress is a large geo. driver of current global livestock:
  - “The thermal environment is the most important ecological factor determining the growth, development, and productivity of domestic animals.” (Collier & Gebremedhin, 2015)
  - “Heat is a major constraint on animal productivity in the tropical belt and arid areas […]. ” (Silanikove, 2000)
  - Has been identified as one of the effect of climate change that farmers need to adapt.

Heat stress and livestock

- Animal's cooling mechanisms are impaired.
- Animal's body temperature rises and it shows signs of heat stress.
- Eats less
- Produces less metabolic heat as a natural protective mechanism.



Source: https://lallemandanimalnutrition.com

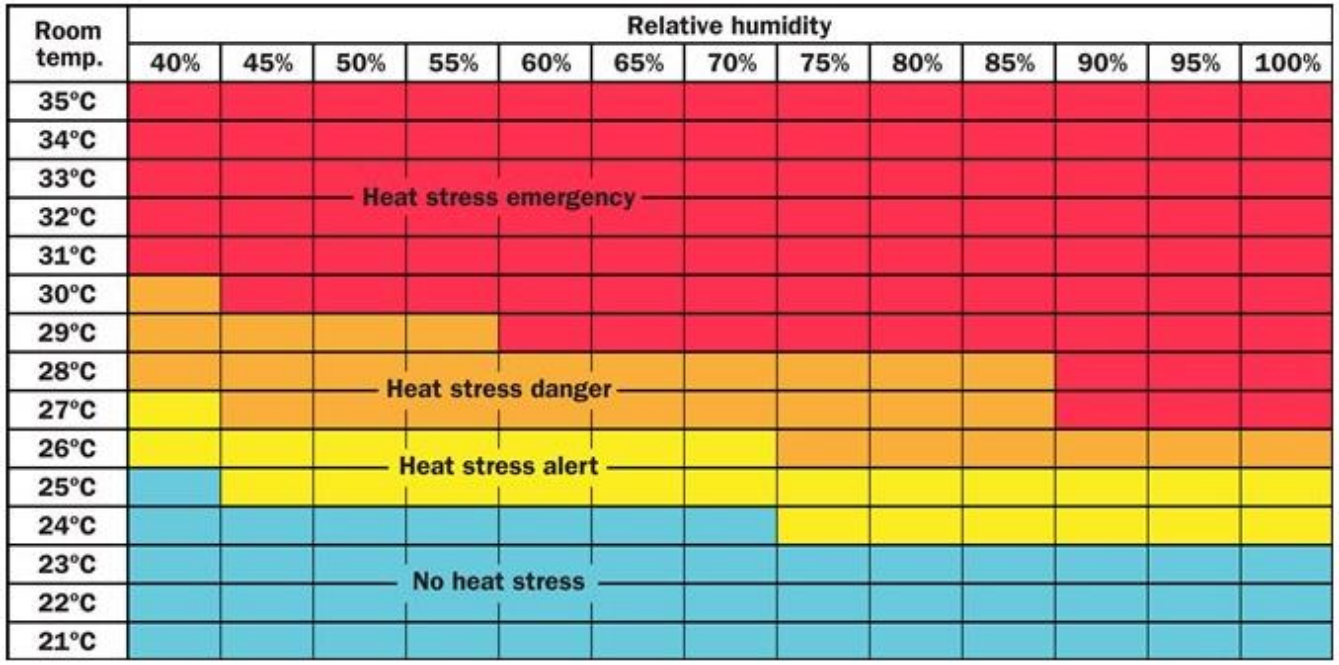
Temperature Humidity Index (THI)

- Easy way to measure and evaluate heat stress

THI = (1.8 × Tdb + 32) – [(0.55 – 0.0055 × RH) × (1.8 × Tdb – 26.8)] (National Research Council, 1971)

where:

Tdb is dry-bulb temperature in °C, Twb is wet-bulb temperature in °C, and RH is Relative humidity %



Adapted from Xin, H. and Harmon (1998)

THI thresholds and response

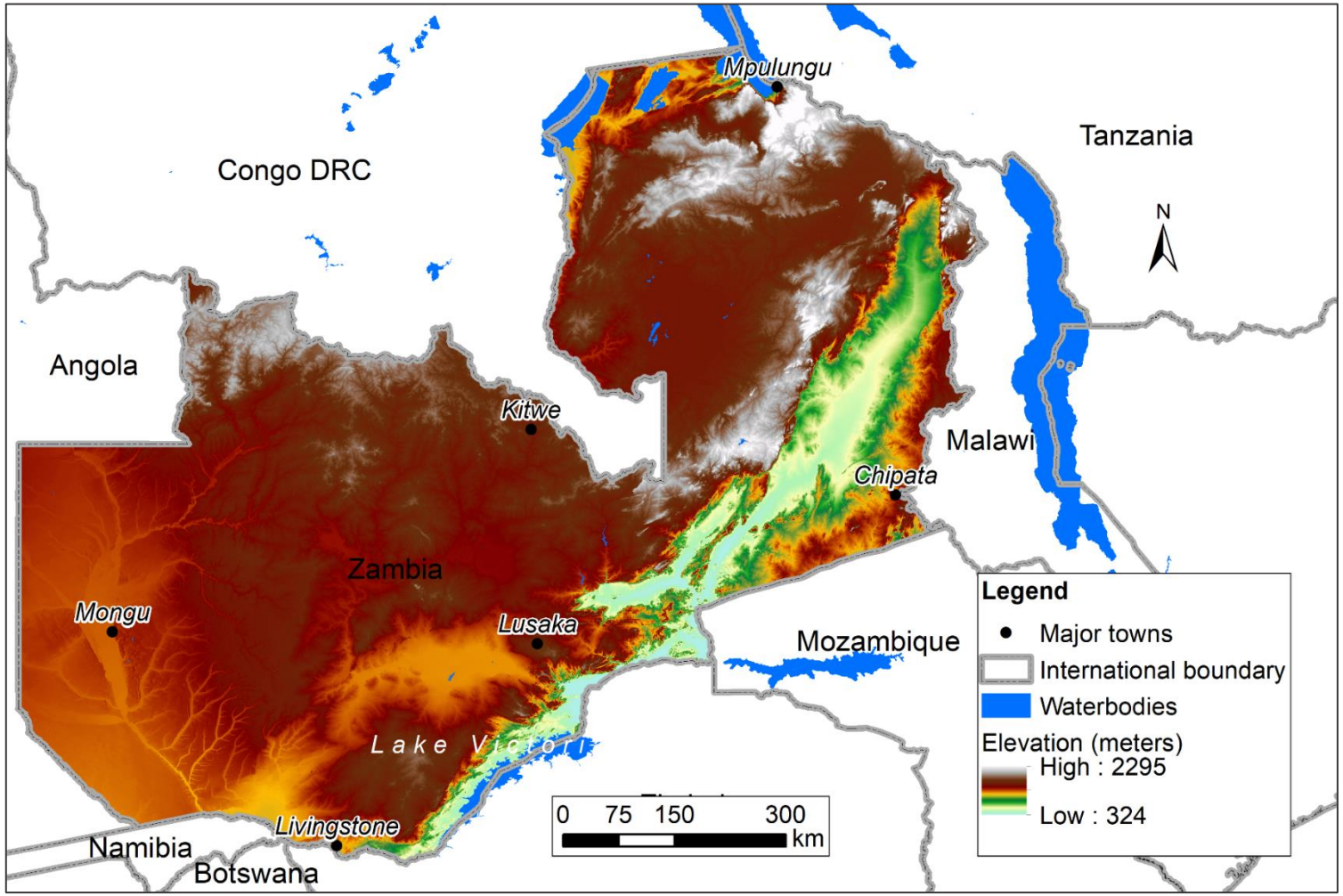
Category	Dairy Cattle	Response
None	THI < 72	i. Both productive and reproductive performance are optimum
Mild	72 ≤ THI < 79	i. Livestock body is able to control the heat stress by chemical and physical means. ii. Livestock seek for shade. iii. Increase in their rectal temperature, respiration rate. iv. Dilation of blood vessels
Moderate	79 ≤ THI < 89	i. Body temperature would increase and productive/reproductive performances are expected to be severely affected. ii. Respiration rate would significantly increase. iii. Dry matter intake and ratio of forage to concentrate intake is expected to decrease. iv. Water intake would significantly increase.
Severe and Danger	THI ≥ 89	i. Respiration and excessive saliva production would increase. ii. The productive/reproductive performances will significantly decrease. iii. Rumination and urination will decrease. iv. In extreme cases, the stress would be significantly extreme and livestock may die.

Heat stress level	Practical example of [Temperature ; Relative Humidity]	Exposure duration	Milk loss under heat stress [kg/h ; kg/cow/day]
Stress Threshold THI [68-71]	[22°C (72°F) ; 50%]	4 hrs/day	[-0.283kg/h ; -1.1kg/cow/day]
Mild-Moderate Stress THI [72-79]	[25°C (77°F) ; 50%]	9 hrs/day	[-0.303kg/h ; - 2.7kg/cow/day]
Moderate-Severe Stress THI [80-89]	[30°C (86°F) ; 75%]	12 hrs/day	[-0.322kg/h ; -3.9kg/cow/day]
Severe Stress THI [90-99]	[34°C (93°F) ; 85%]		Not measured

Source: https://lallemandanimalnutrition.com

Case study: Zambia

- Cool-Dry = May-August; Hot-Dry=September-November; Warm-Wet=December-April
- Excessive heat in the Zambezi and Luangwa valleys
- Population > 18 million as in 2019; annual growth rate of 1.4 %; (World Bank, 2019)

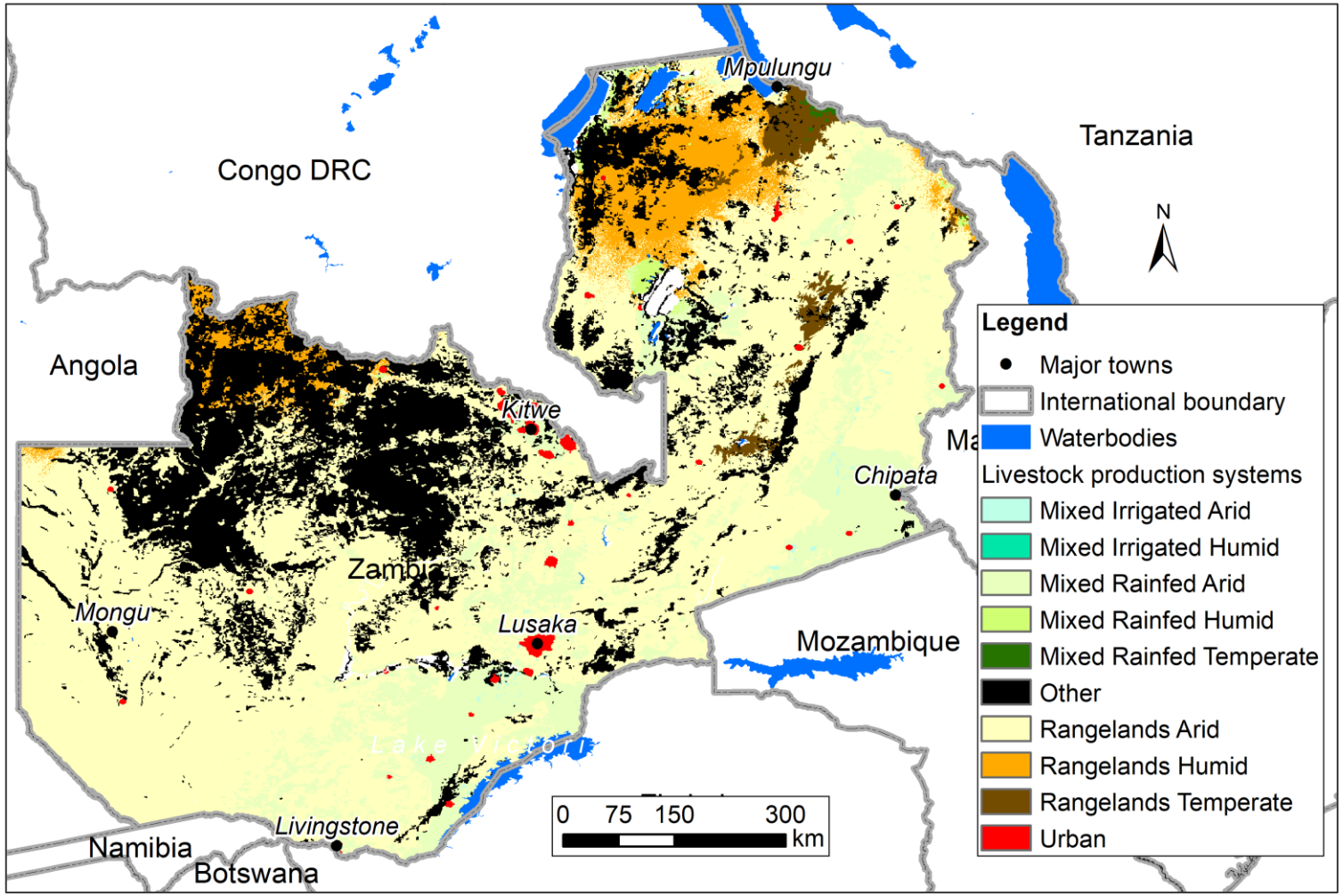


An Overview of the Dairy Industry

- Approximately 3000-4000 smallholder and commercial dairy farmers who produce milk for formal market (ACF, 2012).
- Approximately 300,000 traditional cattle-owning households (World Bank, 2010).
- 215 million litres per year; 15 million litres (53.5%) from smallholder farmers.
- Per capital milk consumption is 24 litres per person per year (Recommended level is 200 litres)
- Farmers faster embracing exotic and cross breeds.

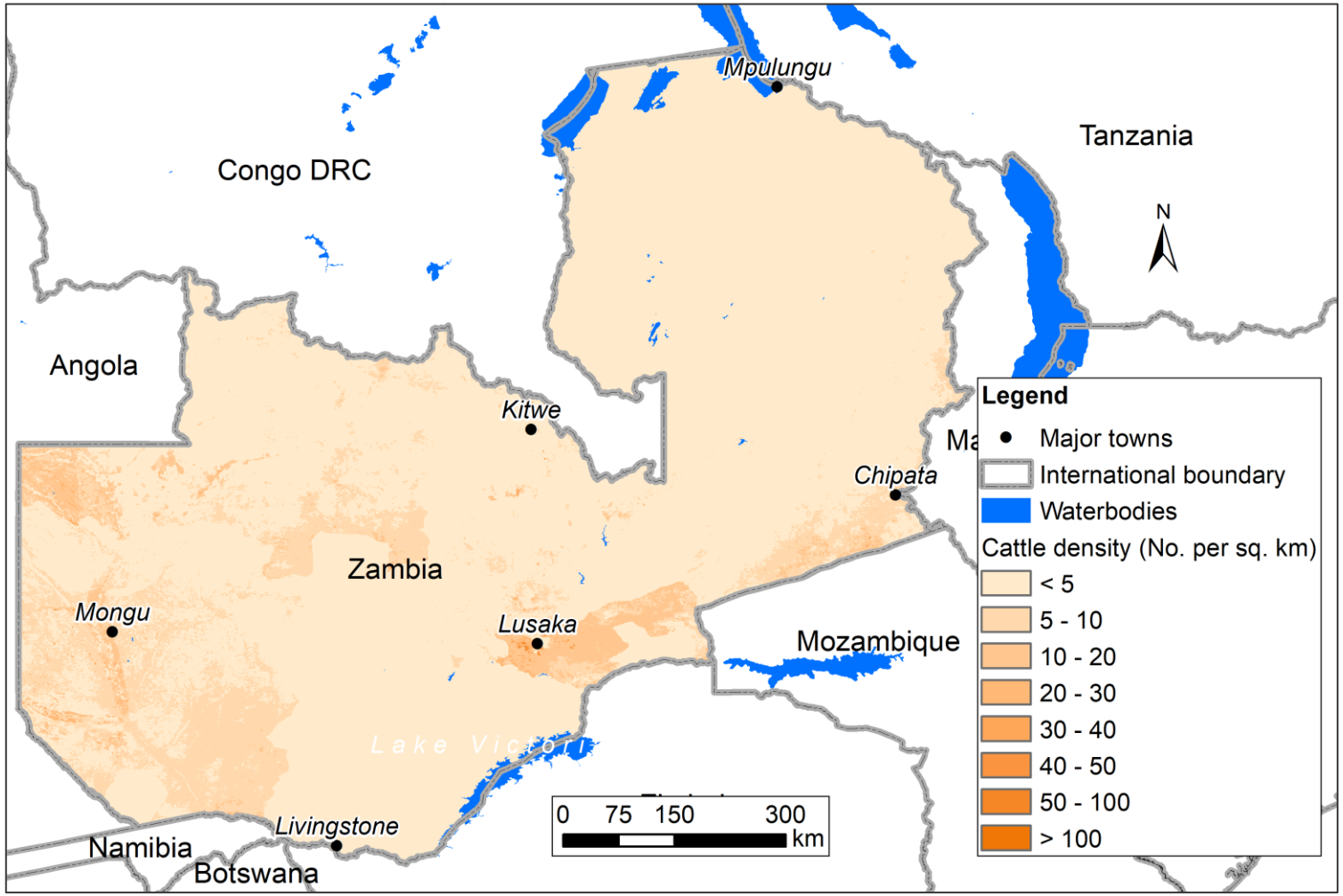
Livestock Production Systems

- Rangelands Arid are dominant



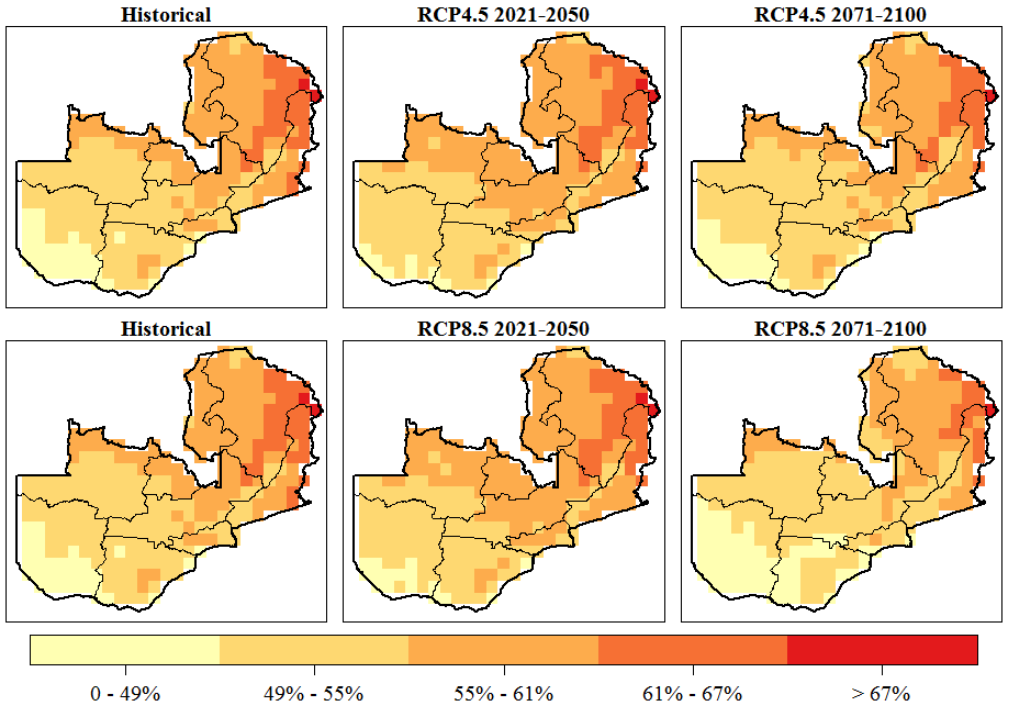
Cattle Density

- Practiced across all of Zambia.
- Concentrations around the southern regions.



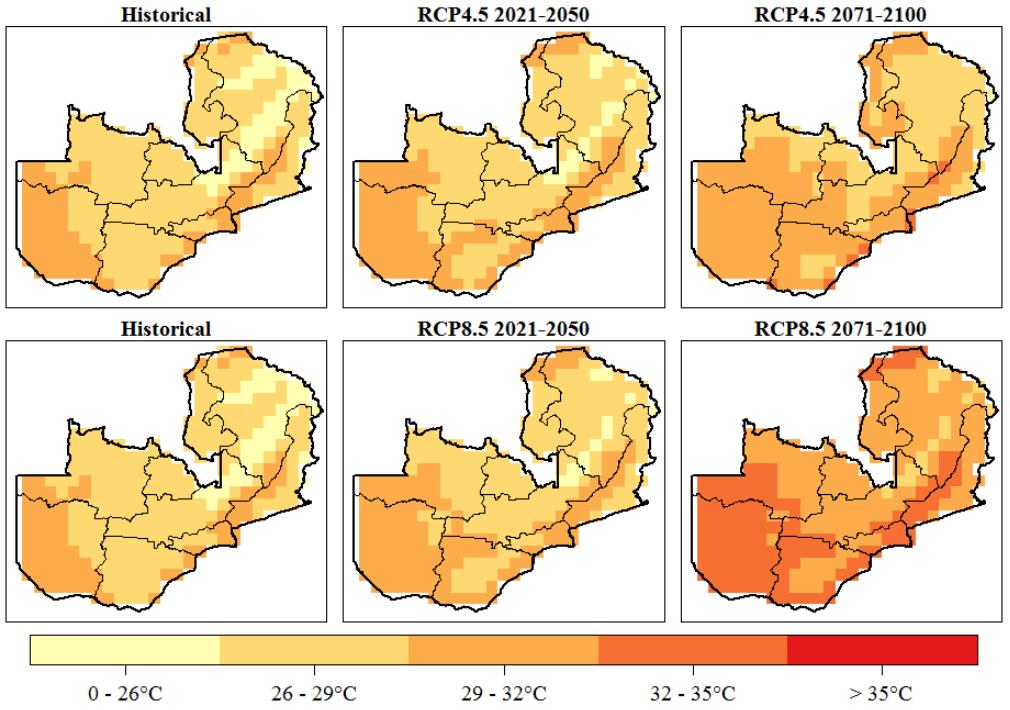
Climate Change Scenarios

Δ in Relative Humidity



%

Δ in Maximum Temperature

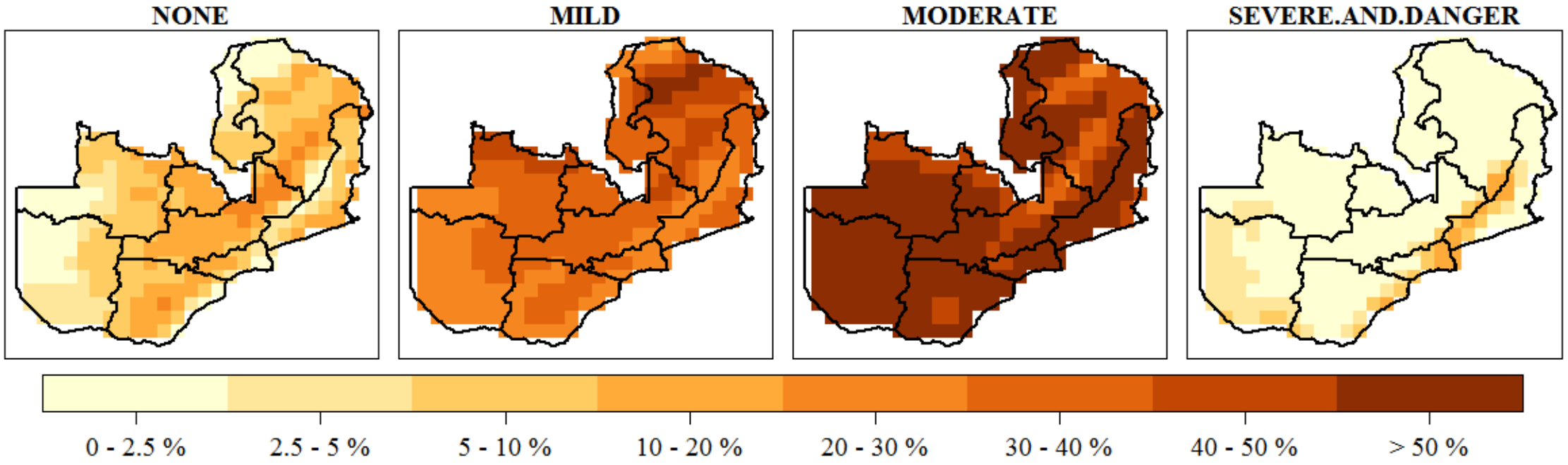


°C

By 2100 maximum temperature is expected to increase by 1.5 and 3.5°C and relative humidity is expected to increase by 4 - 7% based on RCP 4.5 and RCP 8.5 scenarios

Heat Stress Mapping

Frequency of different THI categories for dairy cattle during the historical period (1981-2010)

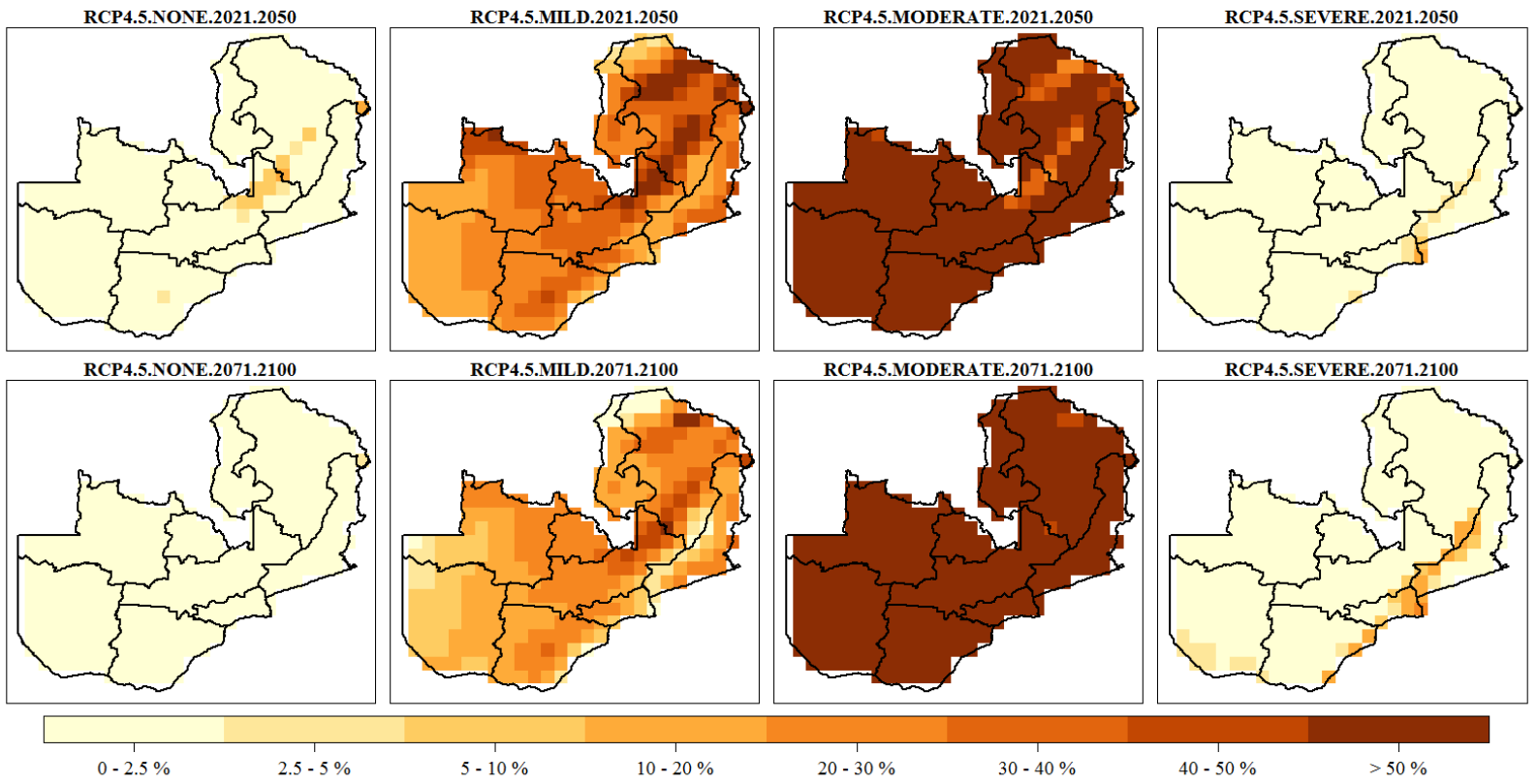


Average severe frequency ranges from 2.5 % in the south to 10 % in the eastern parts; Most of the country is experiencing moderate conditions

Frequency of different THI categories for dairy cattle by 2021-2050 and 2071-2100 periods under RCP 4.5 scenario

Moderate heat stress is dominant

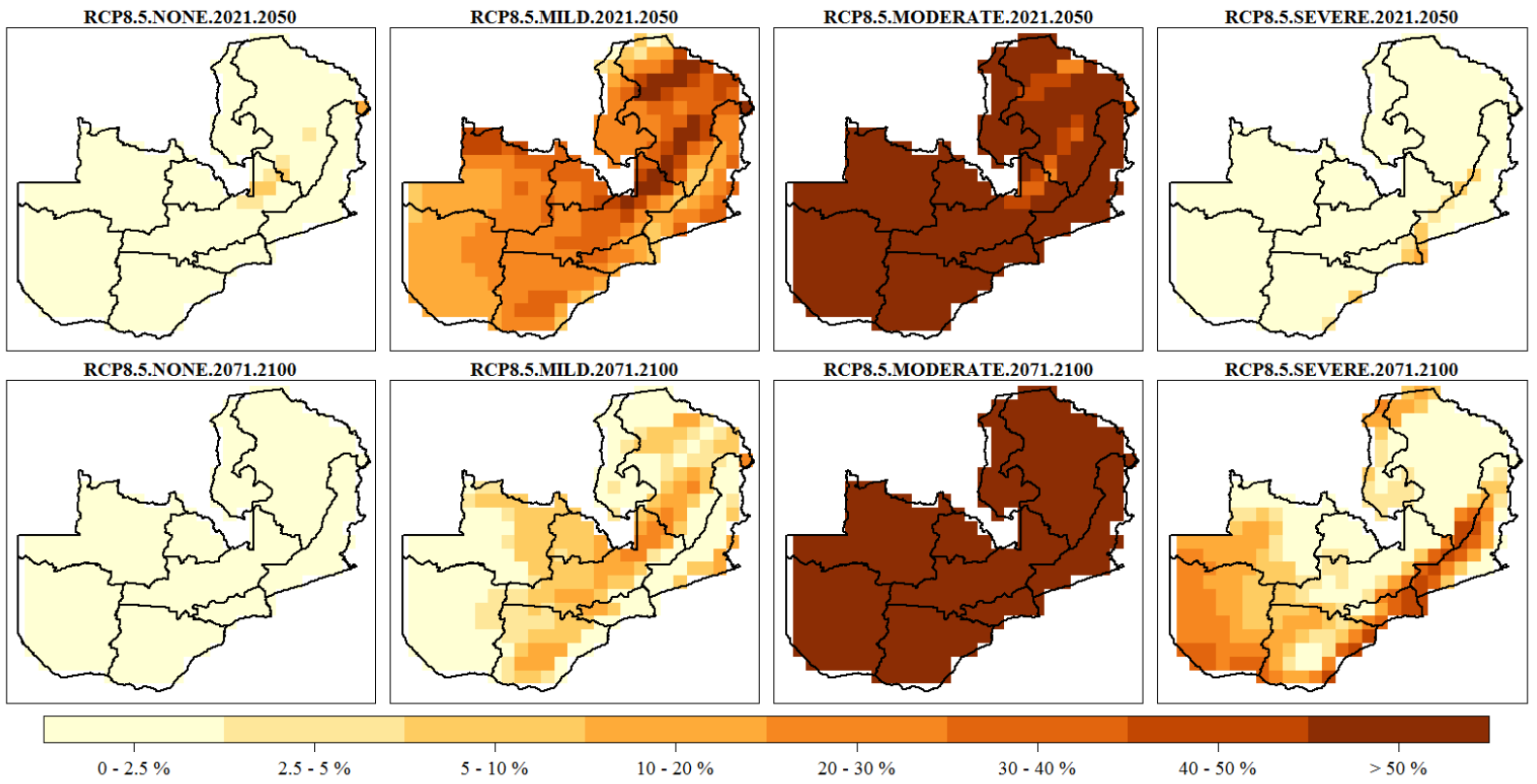
Southern/ Eastern parts are already experiencing severe conditions >10 % of the time



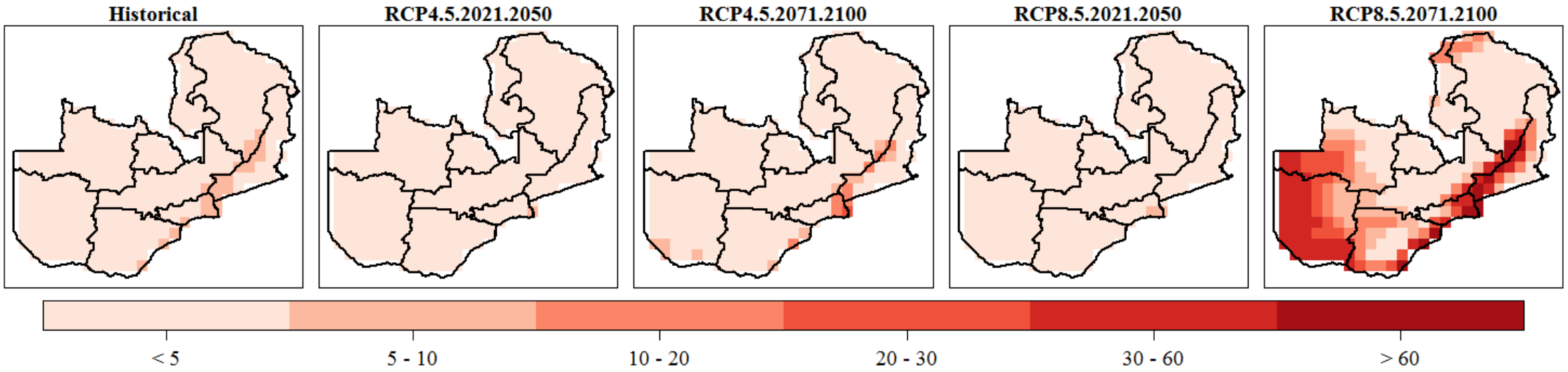
Frequency of different THI categories for dairy cattle by 2021-2050 and 2071-2100 periods under RCP 8.5 scenario

Moderate heat stress is dominant in 2021-2050 period

South western/ Eastern parts are already experiencing severe conditions > 50 % of the time



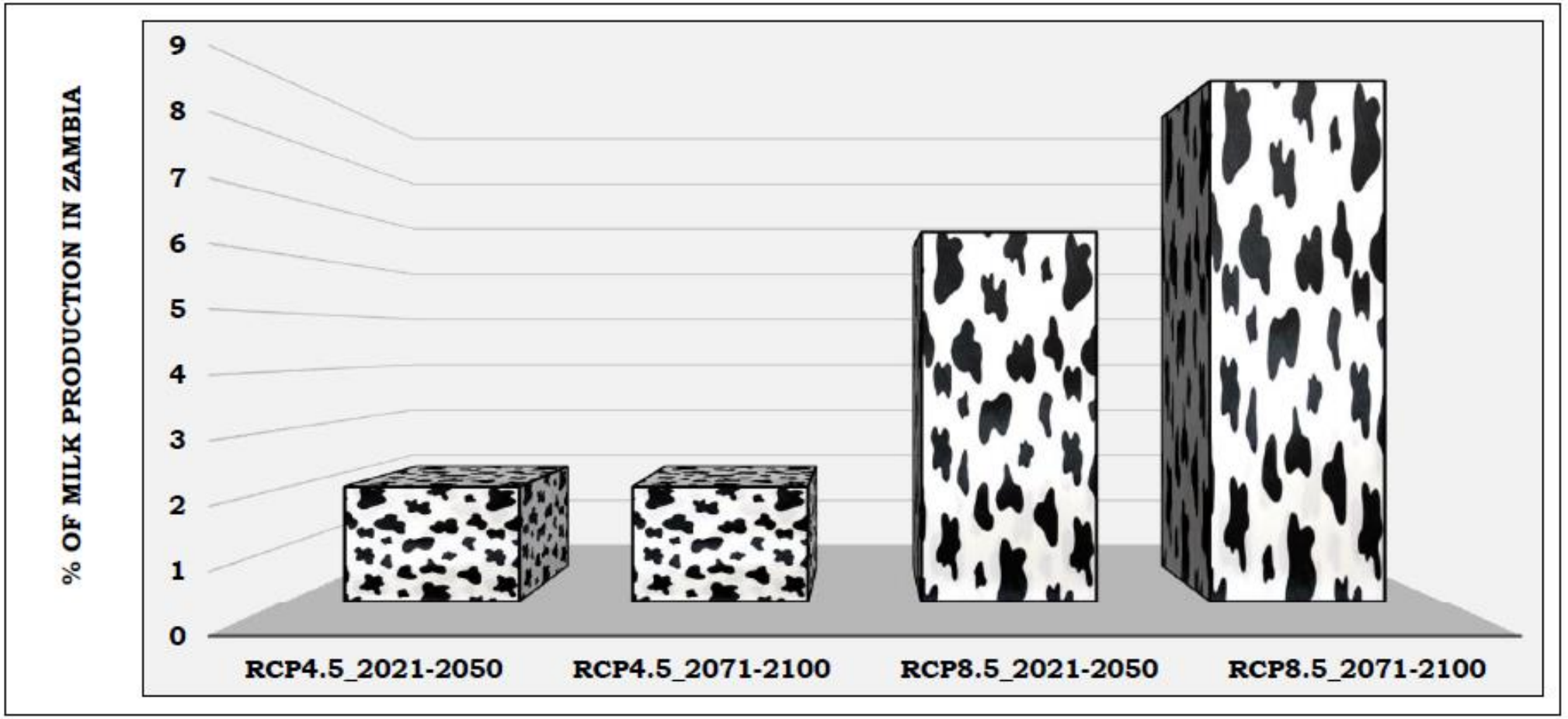
Projected changes in length of consecutive Severe/Danger heat stress condition for dairy cattle by 2021-2050 and 2071-2100 period under RCP4.5 and RCP8.5 scenarios



By 2071-2100, length of Severe/Danger heat stress is expected to be more extended in the southwestern parts/eastern; generally, increase from < 5 days in the historical period to < 60 days based on RCP 8.5 in the southwestern parts/eastern.

Assessing Impacts

Percentage of current milk production in Zambia which will be significantly challenged (at 95% confidence level) by increasing frequency of heat stress



Conclusion

- Most regions have already experienced an increasing trend of severe heat stress historically and the trend is likely to continue in the future.
- The results presented here, might be less severe for highly heat stress adapted breeds or cross-breads. But the pattern of changes should be the same.
- There is a need for experiments to be conducted for local breeds and formulate new THI formulae.
- It’s necessary to adapt to the new climatic conditions in order to maintain the quantity and quality of livestock products.
- We still don’t know how heat stress affects activities at different stages of the value chain.

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